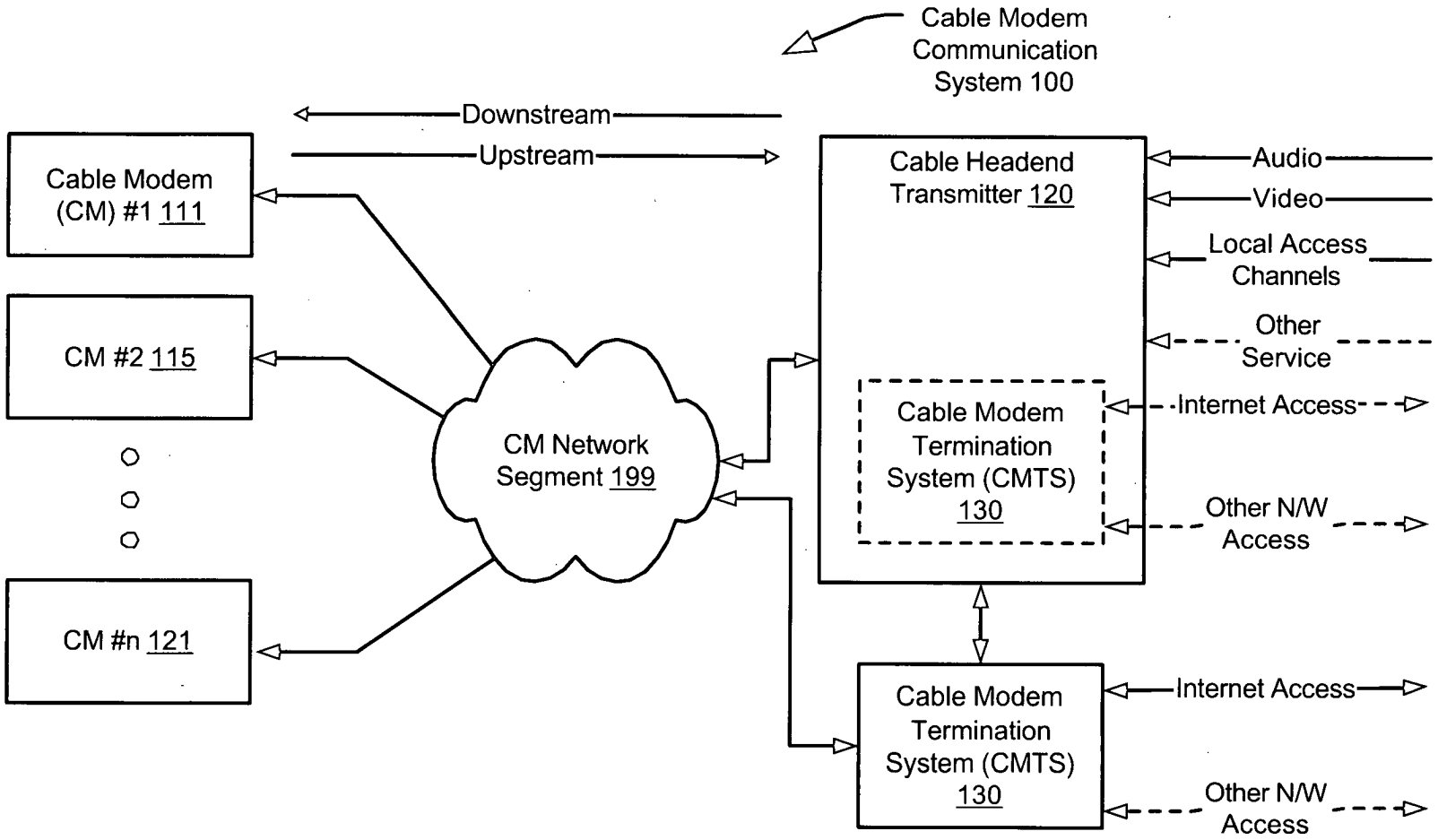

Cable Modem Communication System 100
Downstream
Upstream
Cable Modem (CM) #1 111
CM #2 115
CM #n 121
CM Network Segment 199
Cable Headend Transmitter 120
Cable Modem Termination System (CMTS) 130
Cable Modem Termination System (CMTS) 130
Audio
Video
Local Access Channels
Other Service
Internet Access
Other N/W Access
Internet Access
Other N/W Access

FIG. 1

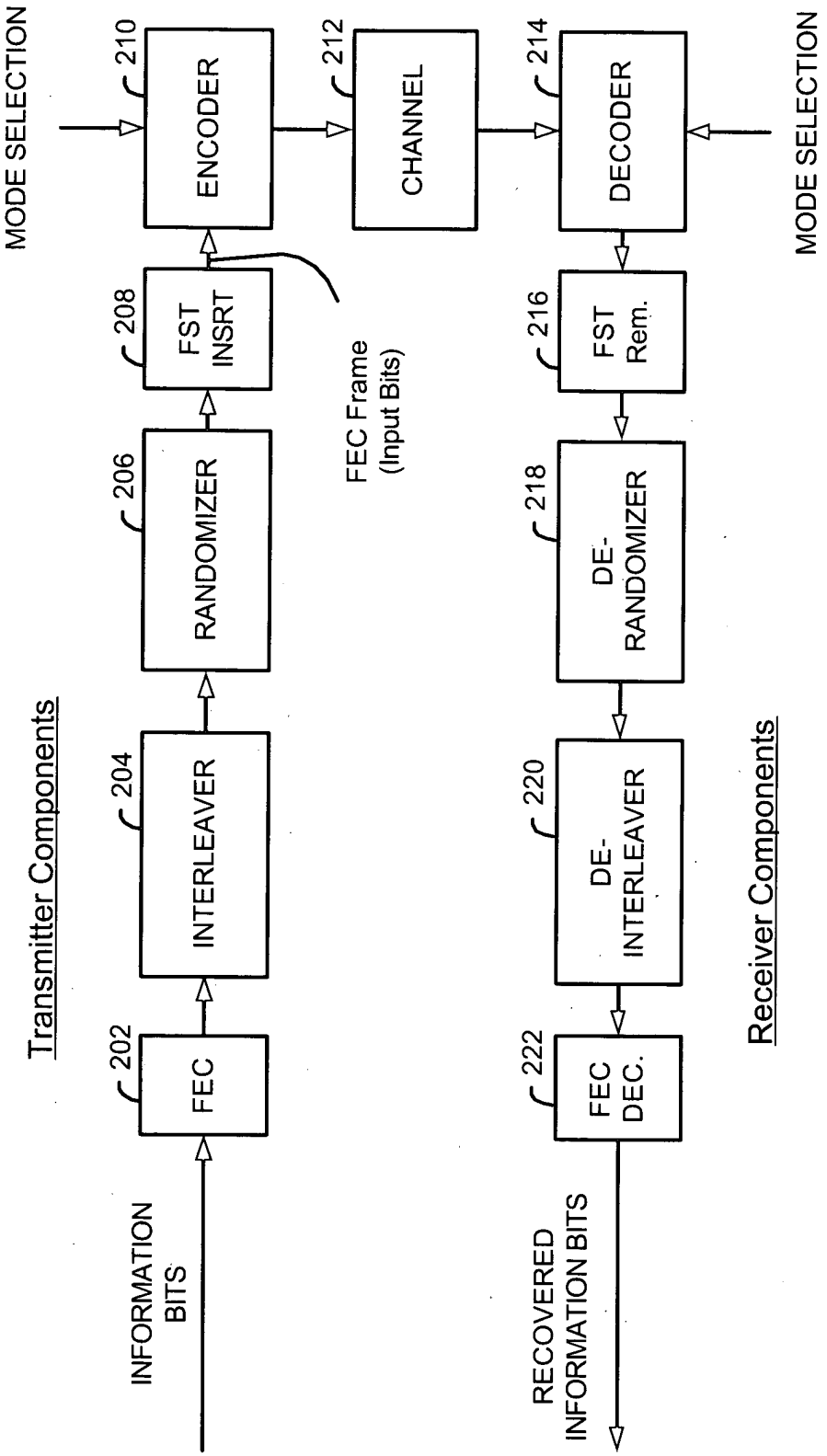

MODE SELECTION
210
ENCODER
212
CHANNEL
214
DECODER
MODE SELECTION
208
FST INSRT
FEC Frame (Input Bits)
216
FST Rem.
206
RANDOMIZER
218
DE-RANDOMIZER
Transmitter Components
204
INTERLEAVER
220
DE-INTERLEAVER
Receiver Components
202
FEC
222
FEC DEC.
INFORMATION BITS
RECOVERED INFORMATION BITS

FIG. 2

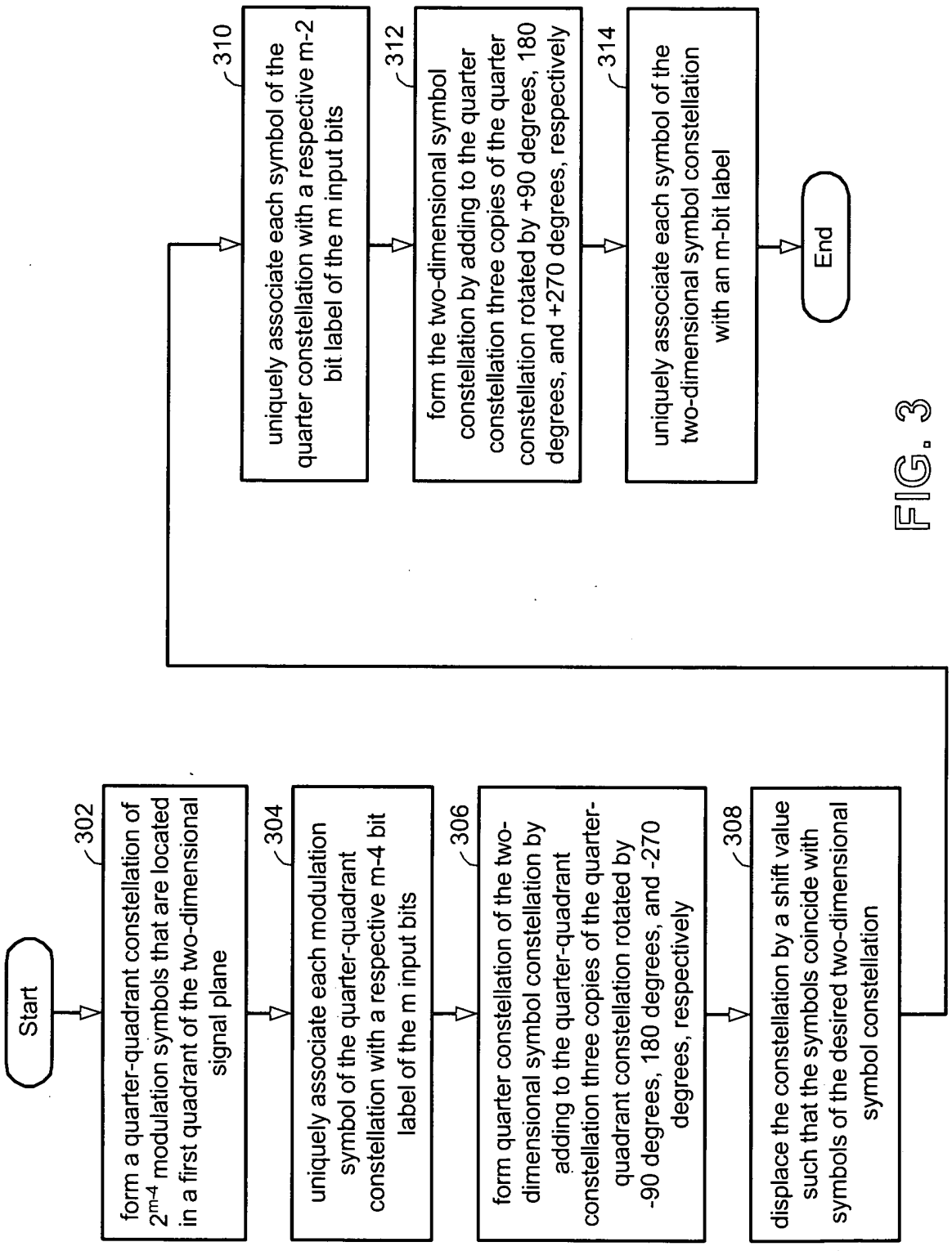

Start
302
form a quarter-quadrant constellation of 2^{m-4} modulation symbols that are located in a first quadrant of the two-dimensional signal plane
304
uniquely associate each modulation symbol of the quarter-quadrant constellation with a respective m-4 bit label of the m input bits
306
form quarter constellation of the two-dimensional symbol constellation by adding to the quarter-quadrant constellation three copies of the quarter-quadrant constellation rotated by -90 degrees, 180 degrees, and -270 degrees, respectively
308
displace the constellation by a shift value such that the symbols coincide with symbols of the desired two-dimensional symbol constellation
310
uniquely associate each symbol of the quarter constellation with a respective m-2 bit label of the m input bits
312
form the two-dimensional symbol constellation by adding to the quarter constellation three copies of the quarter constellation rotated by +90 degrees, 180 degrees, and +270 degrees, respectively
314
uniquely associate each symbol of the two-dimensional symbol constellation with an m-bit label
End

FIG. 3

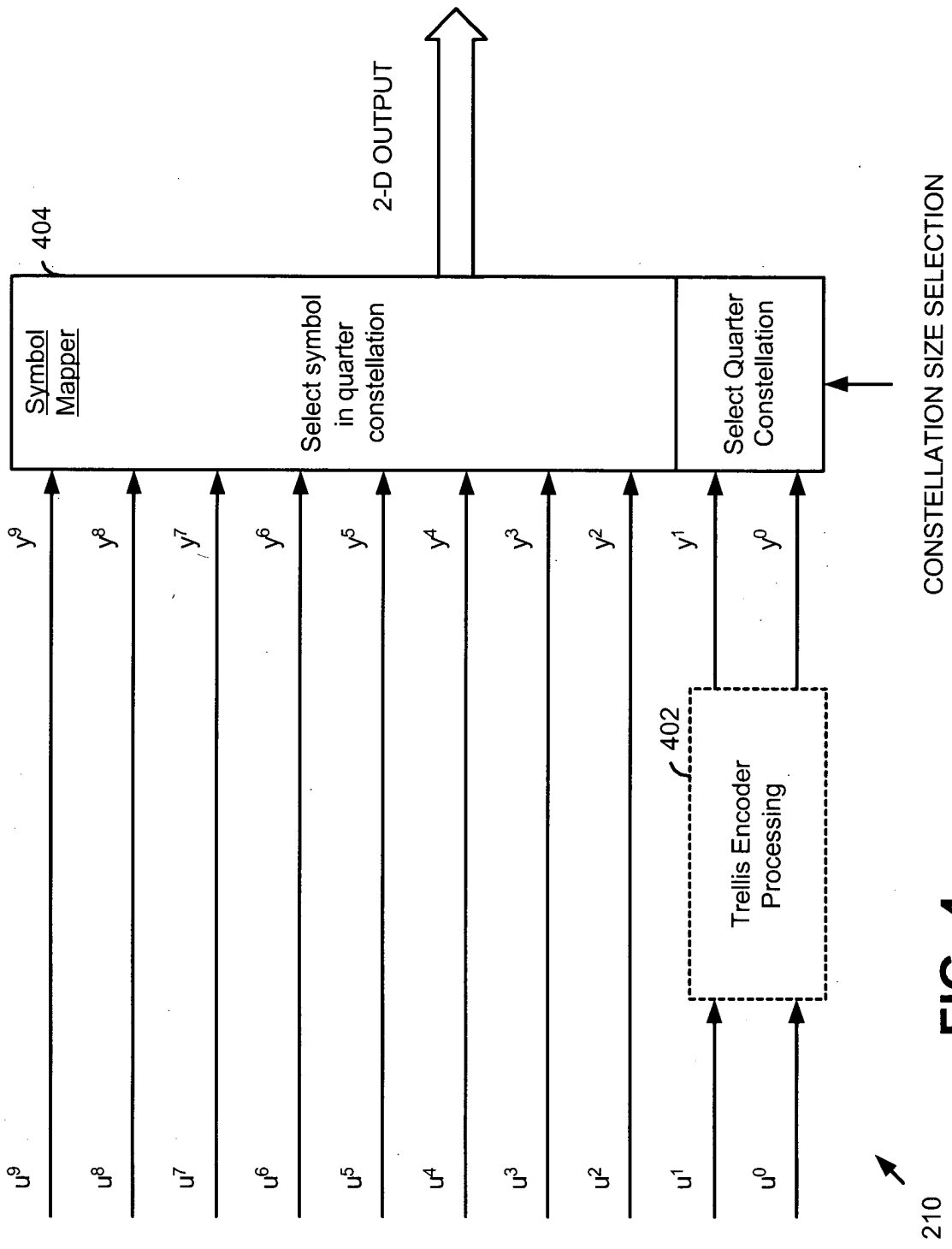
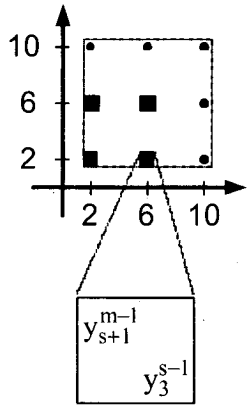

Symbol Mapper
404
2-D OUTPUT
Select symbol in quarter constellation
Select Quarter Constellation
CONSTELLATION SIZE SELECTION
Trellis Encoder Processing
402
210
u9
u8
u7
u6
u5
u4
u3
u2
u1
u0
y9
y8
y7
y6
y5
y4
y3
y2
y1
y0

FIG. 4

Quarter-quadrant (qq) constellation



$$a_{qq}(y_{s+1}^{m-1}, y_3^{s-1}) \in \{2,6,10,...\} + j\{2,6,10,...\}$$

FIG. 5A

Quarte constellation

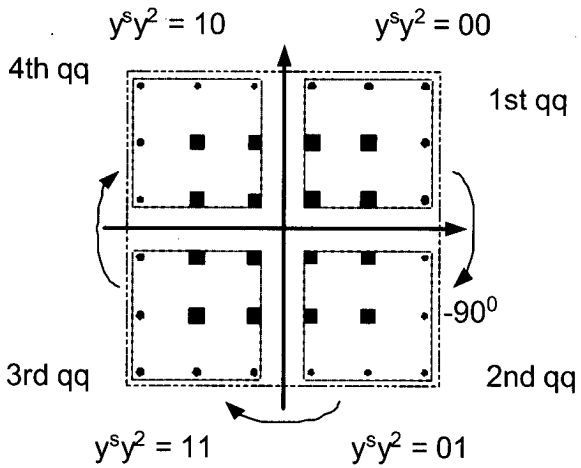


FIG. 5B

Shifted Quarter constellation

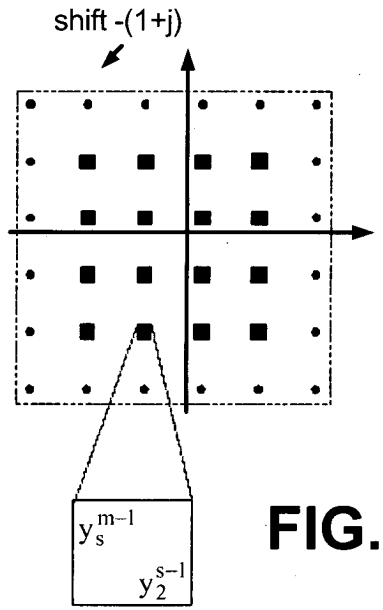


FIG. 5C

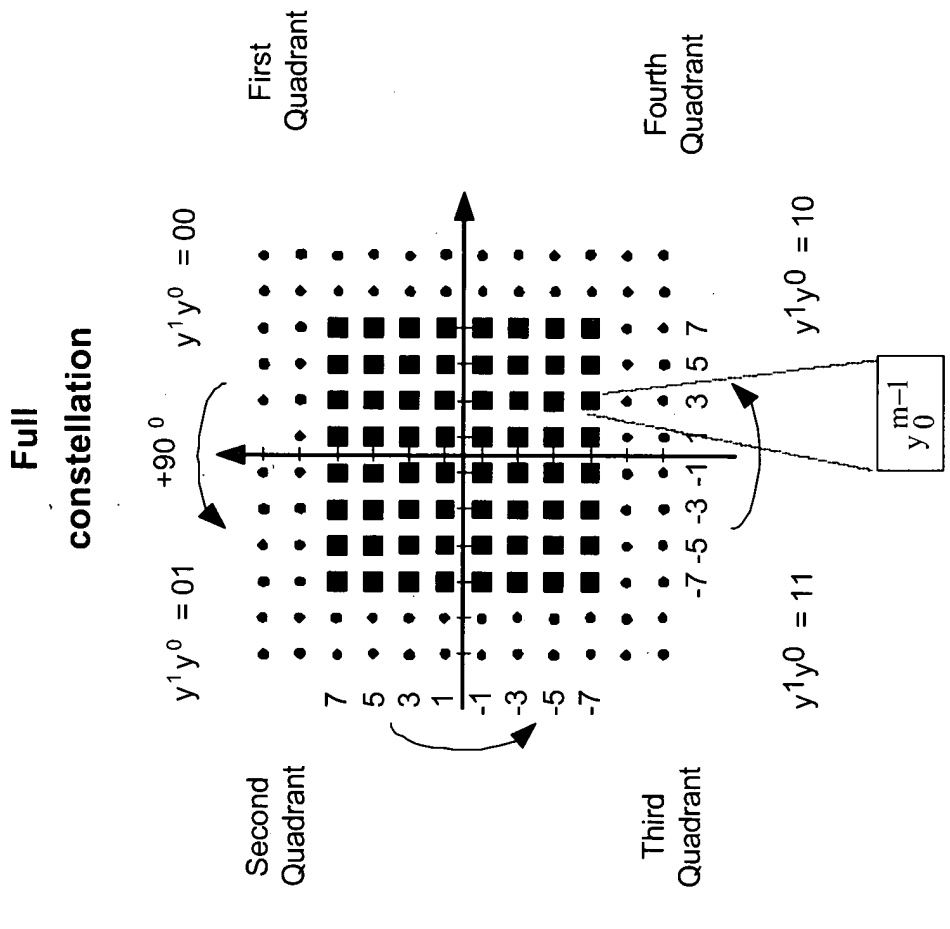

Full constellation
First Quadrant
Second Quadrant
Third Quadrant
Fourth Quadrant
+90 0
y1y0 = 00
y1y0 = 01
y1y0 = 11
y1y0 = 10
7
5
3
1
-1
-3
-5
-7
-7 -5 -3 -1 1 3 5 7
m–1
y 0

FIG. 6

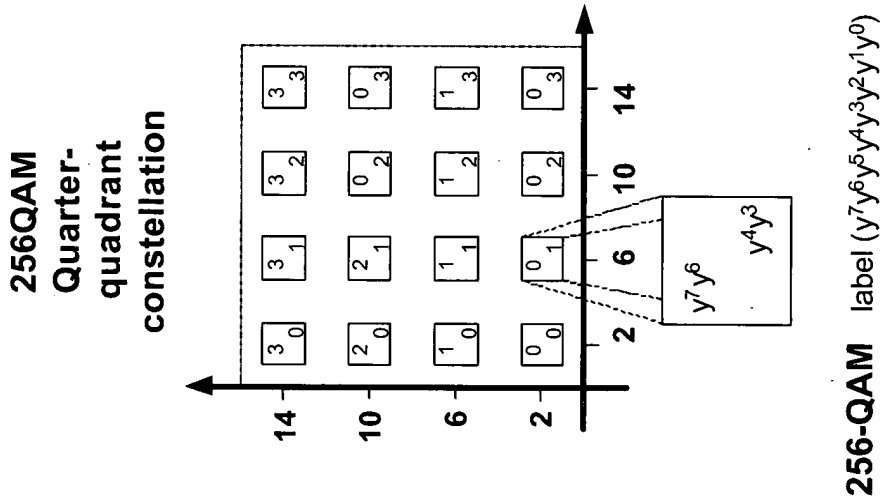

256QAM
Quarter-
quadrant
constellation
14
10
6
2
2
6
10
14
y^7y^6
y^4y^3
256-QAM label ($y^7y^6y^5y^4y^3y^2y^1y^0$)

FIG. 7A

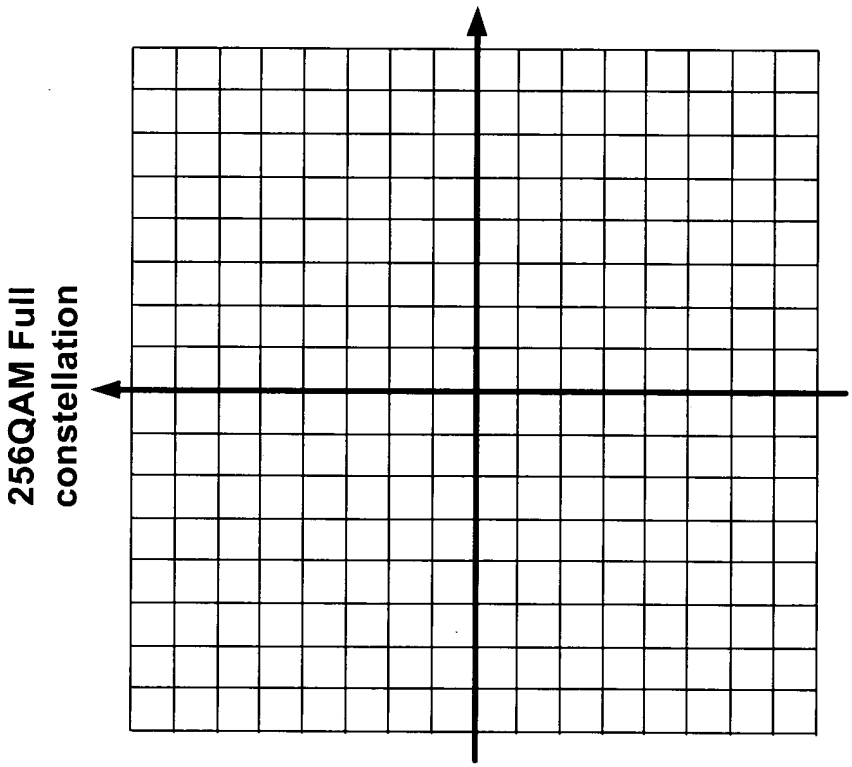

256QAM Full
constellation

FIG. 7B

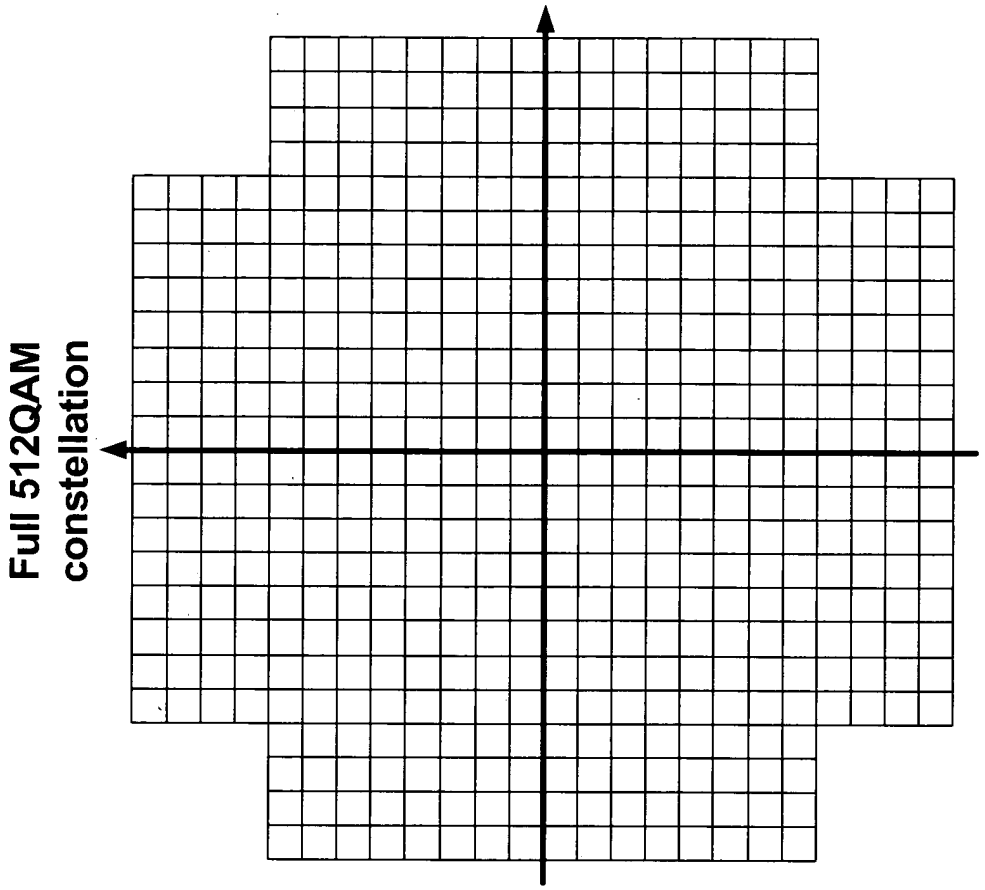

Full 512QAM
constellation

FIG. 8B

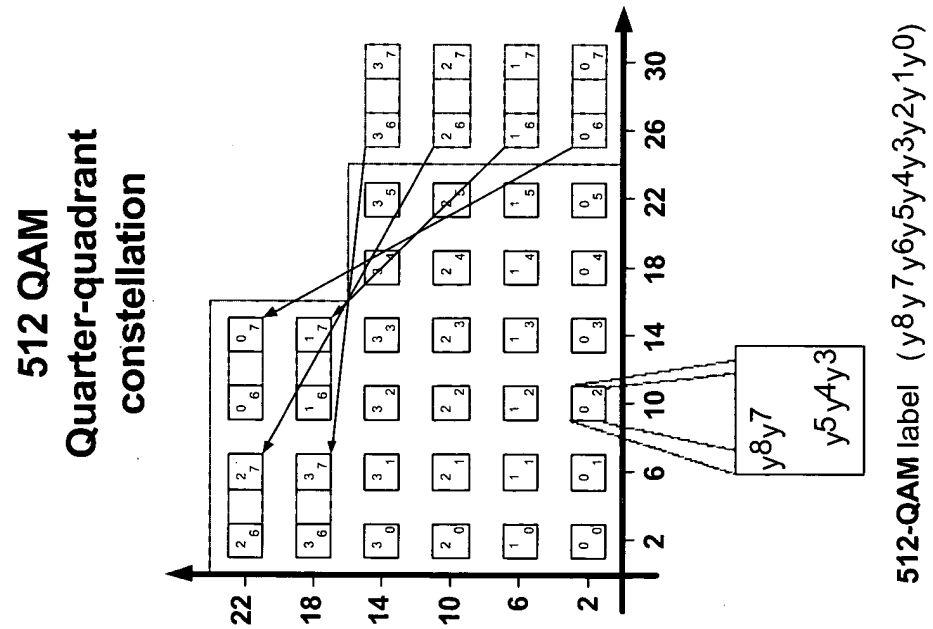

512 QAM
Quarter-quadrant
constellation
2
6
10
14
18
22
26
30
y8y7
y5y4y3
512-QAM label (y8y7y6y5y4y3y2y1y0)

FIG. 8A

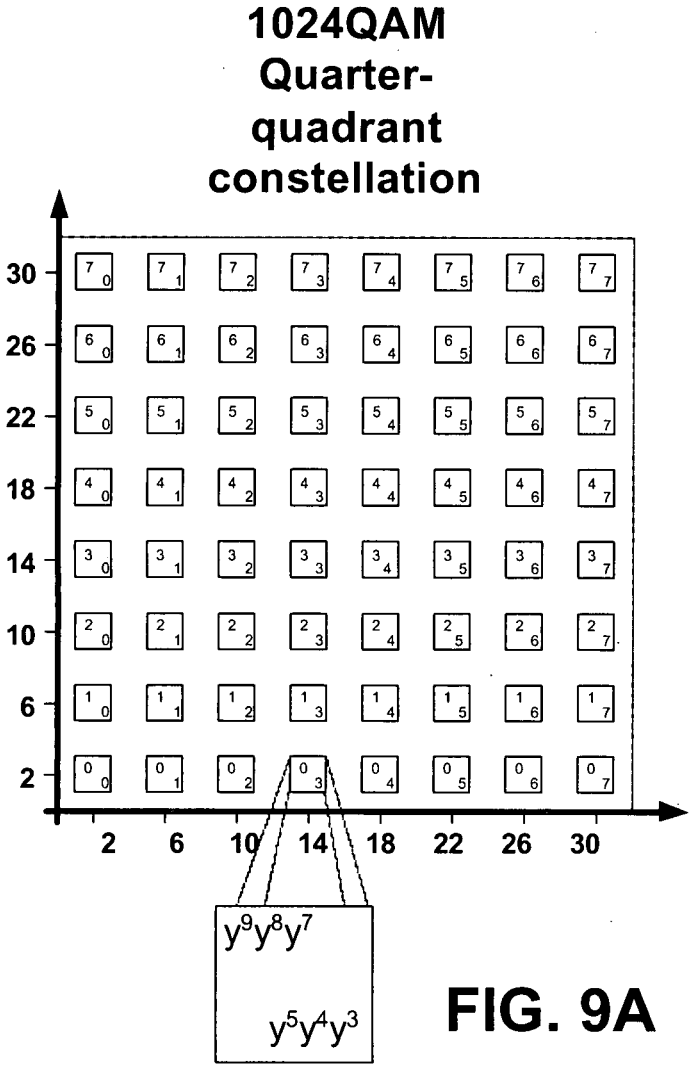


FIG. 9A

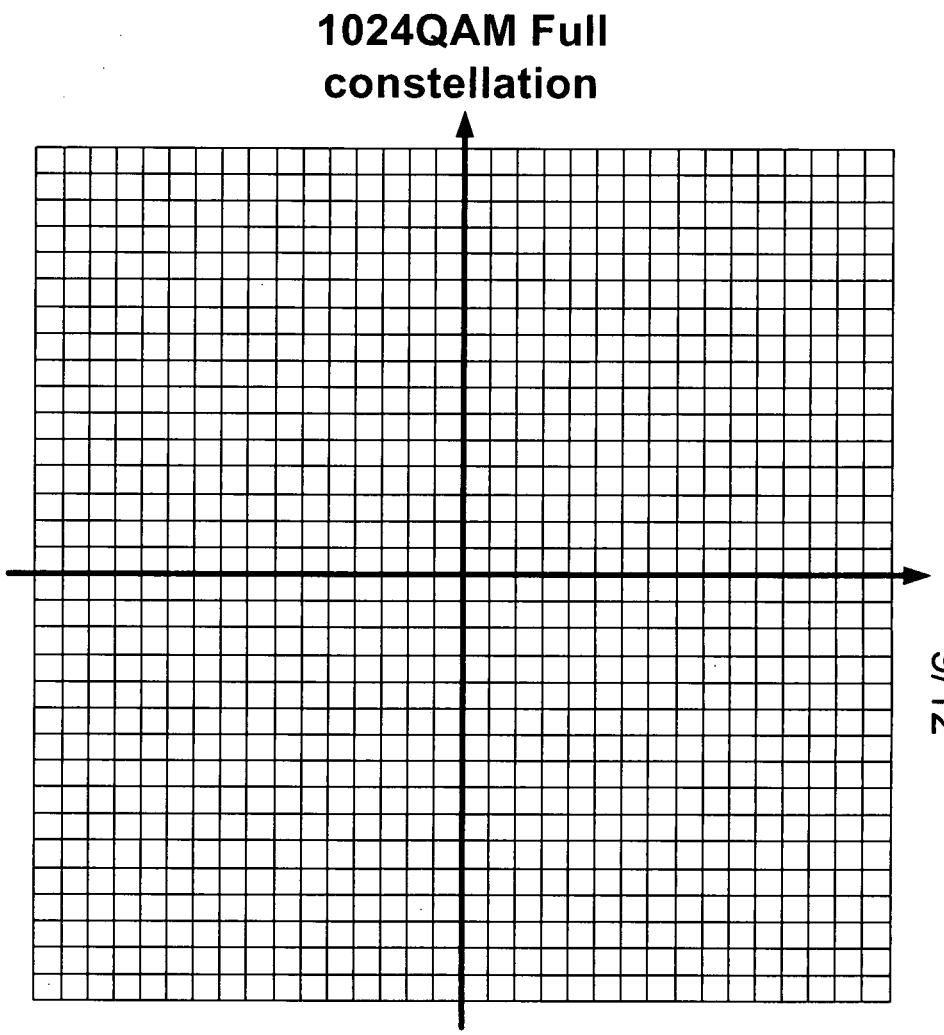


FIG. 9B

1024-QAM label ($y^9y^8y^7y^6y^5y^4y^3y^2y^1y^0$)

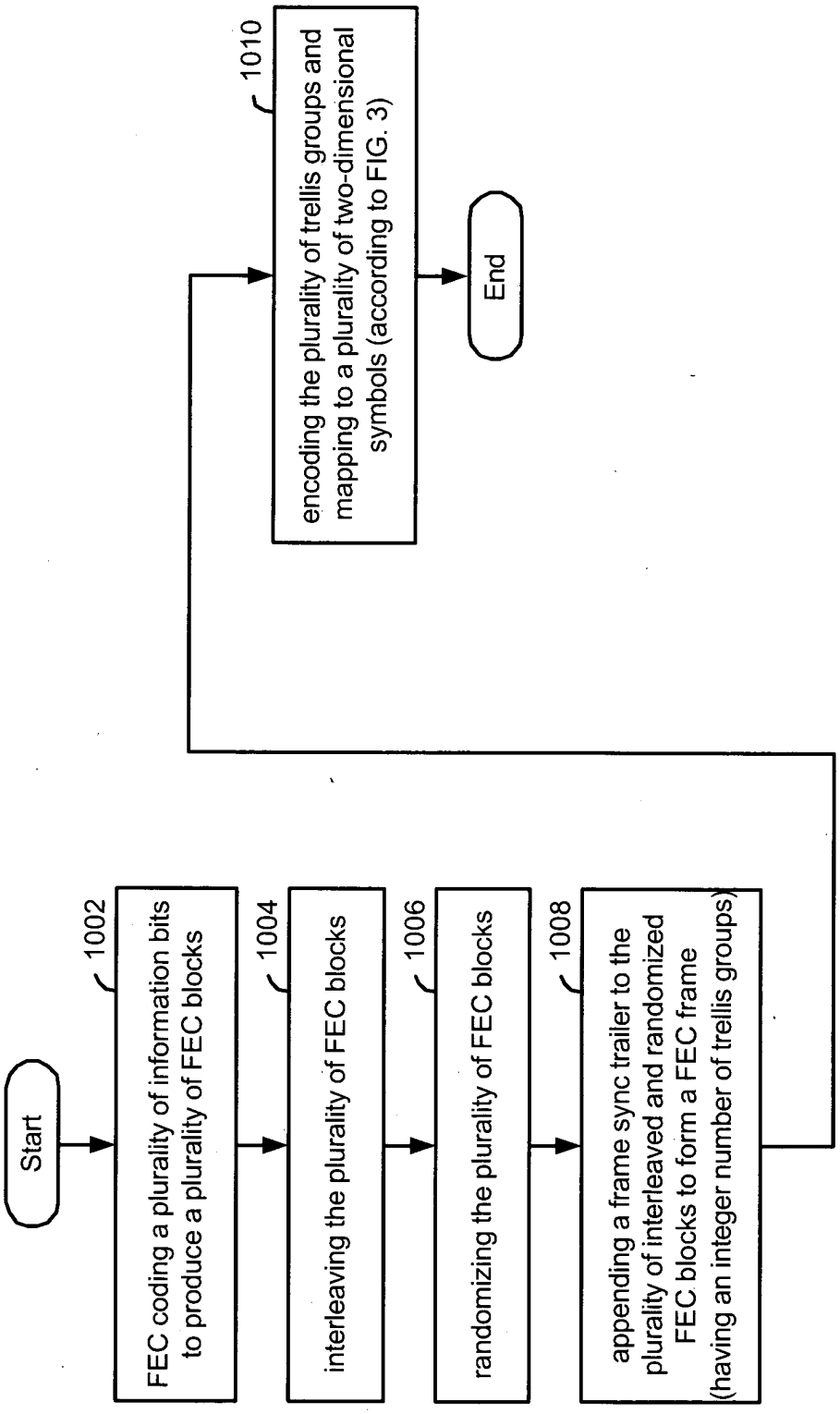

Start
1002
FEC coding a plurality of information bits to produce a plurality of FEC blocks
1004
interleaving the plurality of FEC blocks
1006
randomizing the plurality of FEC blocks
1008
appending a frame sync trailer to the plurality of interleaved and randomized FEC blocks to form a FEC frame (having an integer number of trellis groups)
1010
encoding the plurality of trellis groups and mapping to a plurality of two-dimensional symbols (according to FIG. 3)
End

FIG. 10

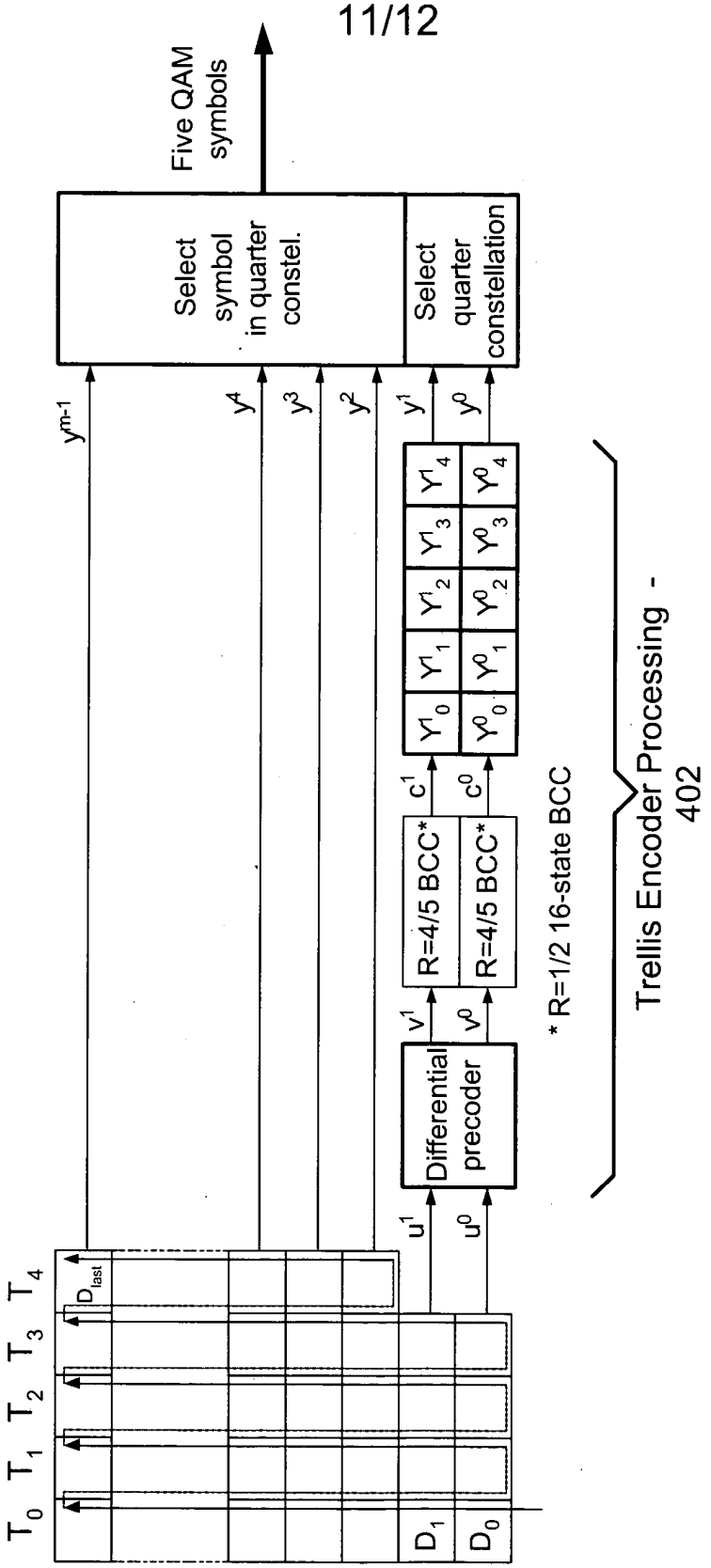

Five QAM symbols
Select symbol in quarter constel.
Select quarter constellation
y^{m-1}
y^4
y^3
y^2
y^1
y^0
Y'_0 Y'_1 Y'_2 Y'_3 Y'_4
Y^0_0 Y^0_1 Y^0_2 Y^0_3 Y^0_4
c^1
c^0
R=4/5 BCC*
R=4/5 BCC*
v^1
v^0
Differential precoder
u^1
u^0
T_0 T_1 T_2 T_3 T_4
D_{last}
D_1
D_0
* R=1/2 16-state BCC
Trellis Encoder Processing - 402

FIG. 11

FEC frame = sequence of 33-, 38-, 43-, or 48-bit trellis groups (TGs)

128QAM

RS block #1 | RS block #2 ——— RS block #77 | 44-bit FST

FST='71E8 4D D4 w0 0'$_{hex}$ inserted as last 44 (u^1,u^0)-bits in FEC frame)

77 x 128x7 + 44 = 69036 bits = 2092 x 33-bit TGs

256QAM (J.83B)

RS block #1 | RS block #2 ——— RS block #88 | 40-bit FST

FST='71E8 4D D4 w0'$_{hex}$ inserted as last 40 (u^1,u^0)-bits in FEC frame)

88 x 128x7 + 40 = 78888 bits = 2076 x 38-bit TGs

512QAM

RS block #1 | RS block #2 ——— RS block #99 | 48-bit FST

FST='71E8 4D D4 w0 00'$_{hex}$ inserted as last 48 (u^1,u^0)-bits in FEC frame)

99 x 128x7 + 48 = 69036 bits = 2064 x 43-bit TGs

1024QAM

RS block #1 | RS block #2 ——— RS block #111 | 48-bit FST

FST='71E8 4D D4 w0 00'$_{hex}$ inserted as last 48 (u^1,u^0)-bits in FEC frame)

111 x 128x7 + 48 = 99504 bits = 2073 x 48-bit TGs

FEC frames contain integer numbers of TGs

w = 4-bit control word indicating the size of the employed interleaver

12/12

FIG. 12